# Key indicator

This page is a companion to the [WMO State of the Global climate](https://library.wmo.int/index.php?lvl=notice_display&id=97) reports. It provides access to the latest versions of selected key global indicators used in the report.

Global climate indicators provide a broad view of climate change at the largest scale, encompassing the composition of the atmosphere, energy changes, and the responses of the land, ocean, and ice. These indicators are closely related to one another. For example, the rise in CO2 and other greenhouse gases in the atmosphere leads to an imbalance of energy and thus warming of the atmosphere and ocean. Warming of the ocean in turn leads to rising sea levels, to which is added the melting of ice on land in response to increasing atmospheric temperatures.

The global indicators draw on a wide range of data sets, which are listed at the bottom of the page. Figures are updated at least annually, with some data sets being updated more frequently.

Under each of the figures, you will find links to the images in multiple file formats (png, pdf and svg), as well as a set of data as shown in the figure in [a common comma-separated values (csv) format](https://help.ceda.ac.uk/article/105-badc-csv).

# Greenhouse gases

Greenhouse gases are gases such as Carbon Dioxide (CO2) and Methane (CH4) that absorb and re-emit infra-red radiation. In the atmosphere, they absorb and re-emit infrared radiation emitted by the surface, ultimately leading to a warming of the atmosphere and surface.

Atmospheric concentrations of greenhouse gases reflect a balance between emissions from human activities, natural sources, and sinks in the biosphere and ocean. Increasing levels of greenhouse gases in the atmosphere due to human activities have been the major driver of climate change since the mid-twentieth century. Global average mole fractions of greenhouse gases are calculated from in situ observations made at multiple sites in the [Global Atmosphere Watch (GAW) Programme](https://public.wmo.int/en/programmes/global-atmosphere-watch-programme) of WMO and partner networks.

## What the IPCC says

[A 1.1](https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf#page=4) Observed increases in well-mixed greenhouse gas (GHG) concentrations since around 1750 are unequivocally caused by human activities. Since 2011 (measurements reported in AR5), concentrations have continued to increase in the atmosphere, reaching annual averages of 410 parts per million (ppm) for carbon dioxide (CO2), 1866 parts per billion (ppb) for methane (CH4), and 332 ppb for nitrous oxide (N2O) in 2019. Land and ocean have taken up a near-constant proportion (globally about 56% per year) of CO2 emissions from human activities over the past six decades, with regional differences (high confidence).

# Global temperature

A key indicator of climate change is the global mean temperature. Global mean temperature measures the change in temperature over time averaged across the Earth's surface. Increased concentrations of greenhouse gases in the atmosphere are the primary driver of the long-term increase in global mean temperature.

Warming of the Earth is not the same everywhere. The land has warmed more rapidly than the ocean and the rate of warming has been highest in the Arctic, which has warmed around two to four times faster than the global mean.

## What the IPCC says

[A.1.2](https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf#page=5) Each of the last four decades has been successively warmer than any decade that preceded it since 1850. Global surface temperature in the first two decades of the 21st century (2001–2020) was 0.99 [0.84 to 1.10] °C higher than 1850–1900. Global surface temperature was 1.09 [0.95 to 1.20] °C higher in 2011–2020 than 1850–1900, with larger increases over land (1.59 [1.34 to 1.83] °C) than over the ocean (0.88 [0.68 to 1.01] °C). The estimated increase in global surface temperature since AR5 is principally due to further warming since 2003–2012 (+0.19 [0.16 to 0.22] °C). Additionally, methodological advances and new datasets contributed approximately 0.1°C to the updated estimate of warming in AR6.

[A.1.3](https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf#page=5) The likely range of total human-caused global surface temperature increase from 1850–1900 to 2010–2019 is 0.8°C to 1.3°C, with a best estimate of 1.07°C. It is likely that well-mixed GHGs contributed a warming of 1.0°C to 2.0°C, other human drivers (principally aerosols) contributed a cooling of 0.0°C to 0.8°C, natural drivers changed global surface temperature by –0.1°C to +0.1°C, and internal variability changed it by –0.2°C to +0.2°C. It is very likely that well-mixed GHGs were the main driver of tropospheric warming since 1979 and extremely likely that human-caused stratospheric ozone depletion was the main driver of cooling of the lower stratosphere between 1979 and the mid-1990s.

# Ocean indicators

The ocean covers nearly 70% of the Earth’s surface. Most of the excess energy that accumulates in the Earth system due to increasing concentrations of greenhouse gases is taken up by the ocean. The added energy warms the ocean and this warming causes the water to expand, which in turn leads to sea-level rise. The melting of ice on the land also adds to sea level rise. The surface layers of the ocean have warmed more rapidly than the interior, mirrored in the rise of global mean sea-surface temperature and in the increased incidence of marine heatwaves.

As the concentration of CO2 in the atmosphere increases, so too does the concentration of CO2 in the ocean. This affects ocean chemistry, lowering the average pH of the water, a process known as ocean acidification, though it should be noted that the ocean remains, on average, slightly alkaline. All these changes have a broad range of impacts and interactions in the ocean and coastal areas.

## What the IPCC says

[A1.6](https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf#page=5) It is virtually certain that the global upper ocean (0-700 m) has warmed since the 1970s and extremely likely that human influence is the main driver. It is virtually certain that human-caused CO2 emissions are the main driver of current global acidification of the surface open ocean. There is high confidence that oxygen levels have dropped in many upper ocean regions since the mid-20th century and medium confidence that human influence contributed to this drop.

[A1.7](https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf#page=5) Global mean sea level increased by 0.20 [0.15 to 0.25] m between 1901 and 2018. The average rate of sea level rise was 1.3 [0.6 to 2.1] mm/yr between 1901 and 1971, increasing to 1.9 [0.8 to 2.9] mm/yr between 1971 and 2006, and further increasing to 3.7 [3.2 to 4.2] mm/yr between 2006 and 2018 (high confidence). Human influence was very likely the main driver of these increases since at least 1971.

[Chapter 2](https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter02.pdf#page=5) Ocean pH has declined globally at the surface over the past four decades (virtually certain) and in all ocean basins in the ocean interior (high confidence) over the past 2-3 decades. A long-term increase in surface open ocean pH occurred over the past 50 million years (high confidence), and surface ocean pH as low as recent times is uncommon in the last 2 million years (medium confidence)

[Chapter 9](https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter09.pdf#page=17) Since the 1980s [marine heatwaves] have also become more intense and longer. Satellite observations and reanalyses of SST show an increase in intensity of 0.04°C per decade from 1982 to 2016, an increase in spatial extent of 19% per decade from 1982 to 2016, and an increase in annual MHW days of 54% between the 1987–2016 period compared to 1925–1954. The SROCC assessed that 84–90% of all MHWs that occurred between 2006 and 2015 are very likely caused by anthropogenic warming. There is new evidence since SROCC that the frequency of the most impactful marine heatwaves over the last few decades has increased more than 20-fold because of anthropogenic global warming. In summary, there is high confidence that MHWs have increased in frequency over the 20th century, with an approximate doubling from 1982 to 2016, and medium confidence that they have become more intense and longer since the 1980s

# Sea ice extent

Sea ice is ice that floats on the surface of the ocean. It affects the transfer of heat, energy, momentum and gases between the atmosphere and ocean. Sea ice also plays an important role in many polar ecosystems. Sea-ice extent is a measure of the area of the ocean covered by sea ice.

Sea ice reflects sunlight and absorbs relatively little compared to dark ocean water. If sea ice cover is reduced, the surface absorbs far more sunlight, warming up. In turn the warming can reduce sea ice cover. This feedback is one reason that the Arctic has warmed faster than the global average.

The formation and persistence of sea ice is different in the northern and southern hemispheres. In the northern hemisphere, ice forms largely within the confines of the Arctic ocean, which is enclosed by the coasts of the northern land masses, and other partly enclosed seas. In the southern hemisphere, the ice forms around the edge of the Antarctic continent.

Because sea ice is floating ice, melting and growth of sea ice have little effect on sea level.

## What the IPCC says

[A1.5](https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf#page=5) Human influence is very likely the main driver of the global retreat of glaciers since the 1990s and the decrease in Arctic sea ice area between 1979–1988 and 2010–2019 (decreases of about 40% in September and about 10% in March). There has been no significant trend in Antarctic sea ice area from 1979 to 2020 due to regionally opposing trends and large internal variability.

[Chapter 2](https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter02.pdf#page=5) Current Arctic sea ice coverage levels are the lowest since at least 1850 for both annual mean and late-summer values (high confidence) and for the past 1000 years for late-summer values (medium confidence). Between 1979 and 2019, Arctic sea ice area has decreased in both summer and winter, with sea ice becoming younger, thinner and more dynamic (very high confidence). Decadal means for Arctic sea ice area decreased from 6.23 million km2 in 1979–1988 to 3.76 million km2 in 2010–2019 for September and from 14.52 to 13.42 million km2 for March. Antarctic sea ice area has experienced little net change since 1979 (high confidence), with only minor differences between sea ice area decadal means for 1979–1988 (2.04 million km2 for February, 15.39 million km2 for September) and 2010–2019 (2.17 million km2 for February, 15.75 million km2 for September)

# Glaciers and ice sheets

Glaciers are formed by snow that falls and compacts into solid ice. The ice can flow downhill and where it reaches warmer altitudes, or reaches the sea, the ice can melt or break off in chunks. Large continuously glaciated areas are known as ice sheets. Currently, there are two ice sheets found on Greenland and Antarctica.

Observations and measurements of glaciers and ice sheets shown that they have been losing mass.

## What the IPCC says

[A1.5](https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf#page=5) Human influence is very likely the main driver of the global retreat of glaciers since the 1990s and the decrease in Arctic sea ice area between 1979-1988 and 2010-2019 (decreases of about 40% in September and about 10% in March). There has been no significant trend in Antarctic sea ice area from 1979 to 2020 due to regionally opposing trends and large internal variability. Human influence very likely contributed to the decrease in Northern Hemisphere spring snow cover since 1950. It is very likely that human influence has contributed to the observed surface melting of the Greenland Ice Sheet over the past two decades, but there is only limited evidence, with medium agreement, of human influence on the Antarctic Ice Sheet mass loss.